

# Purple-top Wilt and Similar Diseases of the Potato

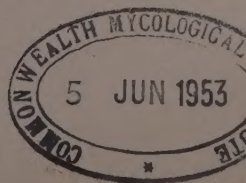
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BULLETIN 511



Purple-top wilt in Katahdin variety.

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# PURPLE-TOP WILT AND SIMILAR DISEASES OF THE POTATO

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### INTRODUCTION

Purple-top wilt is an important potato disease both in Maine and in some of the other potato-producing areas of the United States. All potato varieties apparently are susceptible to infection by the purple-top wilt virus. Severe losses from purple-top wilt infection have been reported from many sections of the country.

The disease is often confused with apical leafroll by both research workers and potato growers.

Purple-top wilt is not a new disease, having been observed in 1915 by Muncie (17)<sup>3</sup> in Michigan, where it was known by the farmers as "moron." Purple-top wilt, however, did not receive much attention by plant pathologists until about 1935, when it became prevalent in some of the potato-producing areas of America.

Leach and Bishop (12) found the disease prevalent in Minnesota in 1935, and Brentzel (6) reported that in 1937 some fields in North Dakota had 20 per cent of the plants infected with purple-top wilt.

Purple-top wilt was first noted in Maine in 1937 when it was prevalent in the Sebago variety (1). The disease was prevalent again in 1938, 1939, and 1940 and caused alarm among some farmers. Almost every field of Sebago, Katahdin, and Chippewa potatoes had purple-top wilt. The amount varied from a few infected plants in some fields to 60 per cent of the plants in other fields.

Decker (8) discovered purple-top wilt in Erie County, New York, in 1939 where approximately 15 per cent of the plants of the Warba variety were infected. Since then purple-top wilt has been reported in many other states. The losses were especially serious in the Southern States where the seed from the Northern States was planted. In 1937 and 1938 the senior writer observed potato fields in Louisiana and Florida where 20 to 75 per cent of the seed failed to grow or produce

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<sup>3</sup> Italic numbers in parentheses refer to Literature Cited, p. 29.



normal plants because of "hair sprout," a condition often developing in purple-top wilt infected seed stocks<sup>4</sup> (3, 13, 21).

Examination of many Maine potato fields from 1942 to 1949 showed that purple-top wilt was common in Aroostook County, varying in amount from a few infected plants in some fields to 50 per cent or more in others. Many seed potatoes from badly infected Maine fields failed to grow or produced weak spindling plants. Large losses resulted.

Very complete descriptions of purple-top wilt—also known as "blue stem"—have been presented by Leach and Bishop (12), Orton and Hill (18), and a number of others. In Maine, it is most prevalent in the Katahdin, Sebago, and Chippewa varieties and less common in Irish Cobbler and Green Mountain though all varieties appear susceptible.

Since purple-top wilt continues to be an important problem in the various potato-producing areas, it is being studied extensively. This publication summarizes results of experiments conducted in Maine pertaining to this and some similar diseases of the potato.

Other research pertaining to purple-top wilt and similar potato diseases in Maine has been summarized by Schultz and Bonde (20), Bonde (1, 2, 3), Bonde and Snieszko (5), Bonde and Schultz (4), and Folsom (10).

## COMPARISON OF PURPLE-TOP WILT AND APICAL LEAFROLL

In view of the fact that purple-top wilt and apical leafroll (20) often are confused by potato growers and research workers, it seems advisable to compare their symptoms.

The first symptoms of purple-top wilt, resulting from current season infection, appear rather late in the season, after the tubers have formed and the plants have nearly reached maximum growth. One or more stems of the plants may be affected. The affected shoots cease to grow and the upper leaves roll upward, especially near the base. The rolled leaves of the pigmented varieties develop a purplish color, particularly at the edges and tips, while the nonpigmented varieties such as Green Mountain develop a pale yellow color. Stems of pigmented varieties also may be more highly colored. The first year symptoms of apical leafroll resemble those of purple-top wilt in that the apical leaves of the infected plants become rolled and the leaves and stems of the pigmented varieties develop a reddish color. This

<sup>4</sup> "Hair sprout" was so serious that a special conference was held in Baton Rouge, Louisiana, in 1938 to discuss the problem.



FIGURE 1. Purple-top wilt in Katahdin. Shoots on right showing rolling of upper leaves which have reddish or purple color. Shoot on left showing later stage, wilting and dying of plant.



FIGURE 2. Purple-top wilt, advanced stage. Foliage and stems dead and limp but no soft rot. They become very dark colored or intense black when affected by frost.



rolling is similar to that associated with primary leafroll, *Rhizoctonia* and *Botrytis* stem girdling, blackleg, and *Verticillium* wilt. The writers, however, have not noted the purplish pigment along the edges and tips of the top leaves of plants with apical leafroll as with purple-top wilt.

Plants with purple-top wilt show necrosis at the plant base and in the roots. The entire plant wilts, becomes flaccid, and gradually dies earlier in the season than normal plants (Fig. 1 and 2). Apical leafroll infected plants are slightly dwarfed and late-maturing and continue to grow even though the vascular system in the lower parts become darkened or brown (Fig. 3 and 4).



FIGURE 3. Apical leafroll in Katahdin. Symptoms similar to early stages of purple-top wilt, but the pigmentation is less intense and the plants do not wilt and die early in the season. They continue to grow after normal plants have matured and died.

As purple-top wilt progresses, aerial tubers are formed in the leaf axils. Apical leafroll tends to induce the formation of extra adventitious buds and branches in the leaf axils.

Tubers from purple-top wilt plants often become soft and spongy. Orton and Hill (19) and Leach and Bishop (12, p. 8 and figs. 6-8)



FIGURE 4. *Left:* Apical leafroll Irish Cobbler. Note slight rolling of upper leaves and close set of tubers. Plants and tubers are smaller and leaves and stems have more reddish or purplish color than healthy plants. *Right:* Healthy control.

noted that the necrosis in the stem regularly extends through the stolons into the tubers causing a characteristic brown discoloration at the stem end along the vascular ring. This discoloration, also noted by Burke (7), in Pennsylvania, has not been observed in Maine. The writers, however, have noted, on cutting numerous tubers from diseased Katahdin and Sebago plants, that the vascular ring in some instances had a slightly grayish appearance, indicating a diseased condition. This appearance, however, was noted only on close examination and did not constitute a market or tuber grade defect. The tubers from apical-leafroll affected plants are smaller than normal and often are borne in necklace-like chains on long stolons and do not become soft or flaccid.

Tubers from purple-top wilt plants of some varieties may form weak sprouts and plants or fail to germinate. Also, small secondary tubers may develop from the mother seed pieces without the formation of shoots and foliage (Fig. 5). The tubers from apical leafroll plants always germinate normally the following spring and produce plants, which, early in the season, are darker green and more erect than normal plants.

If plants are produced from purple-top wilt tubers, the plants





FIGURE 5. *Left:* Small weak Katahdin plants produced from seed tubers harvested from purple-top hills the previous season. Such plants produce very small yields. The small tubers harvested from such plants recover from the disease and produce healthy plants the following year. (See Figure 6.) *Right:* Tubers from Katahdin purple-top wilt plant which produced weak sprouts and small secondary tubers. These tubers failed to produce normal plants.

finally show complete recovery from the disease while apical leafroll, perpetuated from year to year in the seed tubers, shows only slight reduction in severity of symptoms.

Apical leafroll was readily transmitted by the ordinary splice and plug graft methods in the studies conducted in Maine, while purple-top wilt was not.

Apical leafroll (or a disease with similar symptoms) was transmitted by the six-spotted leafhopper (*Macrostelus divisus* (Uhl.)). Purple-top wilt, however, was not transmitted by this insect in the same experiments.

### SYMPTOMS OF PURPLE TOP WILT SIMILAR TO THOSE OF OTHER DISEASES

Samples of seed tubers from potato plants which had been diagnosed as having purple-top wilt were secured for comparison from different areas of Maine during this study. The data obtained showed that several diseases may have symptoms that are readily confused with those of purple-top wilt.



In 1942, tubers from Katahdin plants having symptoms of purple-top wilt were taken from fields in three areas of Maine, the central (Dexter and Lee), the coastal (Machias and Eastport) and the northern (Houlton, Presque Isle, and Fort Fairfield). The tubers were stored in separate hill lots and field-planted the following spring.

Several causes of the "purple-top symptoms" of the preceding year were found. Some of the tubers from the central Maine and coastal fields developed round, shallow stem-end lesions from which *Botrytis* or gray-mold fungus was isolated. However, all of the tubers from these areas produced normal sprouts and plants and good yields when planted.

Such was not the case with the tubers from Aroostook County (northern Maine). None of the 30 hills selected as showing purple-top wilt symptoms produced normal sprouts and plants. Also some failed to germinate. Two selections from Houlton proved to have apical leafroll and two other selections from Aroostook County had a disease of the witches'-broom type.

### EFFECT OF PURPLE-TOP WILT ON STAND AND YIELD

Previous experiments conducted in Maine in 1940 (1) showed that tubers from plants with purple-top wilt often did not germinate or produced small weak plants and therefore were not suitable for seed purposes. Experiments were conducted to obtain more information regarding the effect of this disease on the quality of seed potatoes.

Hills having purple-top wilt were harvested from a field of the Katahdin variety. The tubers from these diseased plants were sorted into three lots: (1) those that were firm and seemed to be normal (44 per cent), (2) those that were slightly wilted (20 per cent), and (3) those that were badly wilted or "spongy" (36 per cent). Observations were made just prior to planting to ascertain whether the sprouts which developed from these tubers were normal. Seventy per cent of the normal appearing tubers sprouted abnormally, either producing "hair sprouts" or failing entirely to germinate. Seventy-six per cent of the slightly wilted tubers failed to produce normal sprouts, and 81 per cent of the badly wilted tubers failed to germinate.

The three lots of seed were planted separately and records obtained regarding the type of plant produced by each tuber. (See Table 1.) It can be seen from the data that the tubers from purple-top wilt plants were not suitable for seed purposes. Even the firm tubers from the diseased hills produced high percentages of dwarfed plants and missing hills.

TABLE 1

Effect of Purple-Top Wilt on the Amount of Tuber Wilting Produced in Katahdin Potatoes and the Plant Symptoms Resulting from Planting Seed Tubers Having Different Degrees of Wilting—1943

Condition of seed tubers <sup>1</sup>	Tubers in each class <sup>2</sup>	Tubers with abnormal sprouts <sup>3</sup>	Kind of plants produced			
			Normal	Slightly dwarfed	Very dwarfed	No plants (missing hills)
	%	%	%	%	%	%
Firm	44	70	43	3	17	37
Slightly wilted	20	76	50	3	6	41
Badly wilted	36	81	3	0	16	81
Apical leafroll control tubers	—	0		100	0	0
Healthy control tubers	—	0	95	5	0	0

<sup>1</sup> Tubers with different degrees of firmness were planted separately, and the plant symptoms that developed were recorded.

<sup>2</sup> Tubers from purple-top wilt plants of the Katahdin variety were harvested, and separated into three classes according to the degree of wilting.

<sup>3</sup> Mostly "hair sprouts" or failed to germinate.

It should be noted from the data in Table 1 that 95 per cent of the healthy control tubers gave normal plants and that there were no missing hills or weak plants. Of interest also is the fact that all of the apical leafroll seed tubers included for comparison produced plants which were only slightly dwarfed.

It has been observed that often only some of the stalks of a potato plant are infected with purple-top wilt. Frequently some of the tubers attached to the diseased stalks are wilted and spongy. The wilted tubers generally are nearest the soil surface. A study was made to determine if purple-top wilt infected tubers were borne only by infected stalks. Tubers from a number of different lots of purple-top wilt plants were examined for sprout formation and then were planted in the field where observations were made of the plant symptoms and the stand that developed.

The experiment showed (Table 2) that the cause of the disease is present not only in tubers from diseased stalks, but also in many of the tubers from apparently healthy stalks, although tubers from diseased stalks produce more affected plants.

For all tubers tested, only 50 per cent of those from the healthy stalks produced normal plants; 20 per cent of the plants were dwarfed and produced no crop; and 22 per cent failed to germinate. Of the tubers from the diseased stalks, 37 per cent failed to grow, and an additional 37 per cent produced small plants with no marketable potatoes.

TABLE 2

Percentage of Tubers with Abnormal Sprouts and the Effect on Stand in the Field of Planting Seed Tubers Harvested from the Healthy and Diseased Parts of Purple-Top Wilt Plants—1943

Variety	Part of plant <sup>1</sup>	Tubers with abnormal sprouts <sup>2</sup>	Kind of plants produced			
			Normal	Slightly dwarfed	Very dwarfed	No plants (missing hills)
		per %	%	%	%	%
Katahdin	Healthy stalks from diseased plants	80	50	8	20	22
	Diseased stalks	82	24	2	37	37
	Healthy controls	0	98	2	0	0
Sebago	Healthy stalks from diseased plants	50	66	27	0	7
	Diseased stalks	72	28	50	13	9
	Healthy controls	0	91	9	0	0

<sup>1</sup> Tubers from the healthy and diseased parts of the same plant were harvested separately and were planted in the field where observations were made on the plants produced by them.

<sup>2</sup> Either weak sprouts known as "hair sprouts" or failure to emerge and produce plants.

Purple-top wilt affected the Sebago variety less than it did the Katahdin. Healthy stalks of Sebago tubers produced only 7 per cent missing hills compared with 22 per cent for the Katahdin variety. The seed tubers from the diseased Sebago stalks gave 9 per cent missing hills compared with 37 per cent for the Katahdin variety.

Hills having tops with symptoms of purple-top wilt were dug during the fall of 1942 and the tubers were stored in separate bags.<sup>5</sup> The potatoes from the different hills were examined and separated into two lots, one lot consisting of the soft and wilted tubers and the other lot of those tubers which were firm and appeared to be normal. The tubers were put into storage and planted in the field in 1943.

The firm tubers from purple-top wilt hills of the Katahdin variety produced only 12 per cent normal plants and those of the Sebago variety 44 per cent normal hills. The soft Katahdin tubers produced no normal plants and 62 per cent failed to grow. In contrast, the soft, wilted tubers of the Sebago variety produced 26 per cent normal plants and only 7 per cent failed to grow (Table 3). The firm tubers from purple-top wilt hills of the Katahdin variety yielded only 82 barrels per acre or 106 less barrels per acre than the healthy stock. (A barrel as used in this paper contains 11 pecks or 2.75 bushels.) In contrast, tubers from purple-top Sebago hills yielded only 14 barrels less per acre than the healthy. The soft tubers from the diseased Katahdin plants

<sup>5</sup> The potatoes were placed in storage September 15, 1942, and were removed April 8, 1943.



TABLE 3

Effect of Purple-Top Wilt on Type of Plants Produced and Yield in the  
Katahdin and Sebago Varieties—1943

Variety	Kind of seed tubers	Kind of plants produced				Yield per acre <sup>1</sup>	Significance <sup>2</sup>
		Normal	Slightly dwarfed	Very dwarfed	No plants (missing hills)		
		%	%	%	%	Bbls. <sup>3</sup>	
Katahdin	Healthy hills (controls)	100	0	0	0	188	—
	Purple-top wilt hills						
	Hard tubers <sup>4</sup>	12	17	44	27	82	**
	Soft tubers <sup>4</sup>	0	25	13	62	56	**
Sebago	Healthy hills (controls)	80	20	0	0	158	—
	Purple-top wilt hills						
	1st year removed						
	Hard tubers <sup>4</sup>	44	42	14	0	144	N.S.
	Soft tubers <sup>4</sup>	26	40	27	7	72	N.S.
	Purple-top wilt hills						
	2nd year removed	90	8	2	0	212	N.S.

<sup>1</sup> Based on 15 replicated 4-hill plots for each yield rate given.

<sup>2</sup> N.S. differences not statistically significant. \*\* Differences highly significant.

<sup>3</sup> One barrel is 2.75 bushels.

<sup>4</sup> Hills having purple-top wilt were harvested in 1942 for planting in 1943. The wilted or soft tubers from each hill were separated from those that were firm and normal in appearance. These were planted separately in 1943.

yielded only 56 barrels per acre contrasted with a yield of 72 barrels per acre from similar seed in the Sebago variety.

The 1943 results confirm those secured earlier by showing that purple-top wilt affects the Katahdin variety more than it does the Sebago. When present in large amounts in Katahdin seed stocks the disease resulted in a high percentage of very weak plants and missing hills. In the Sebago variety, the disease causes less dwarfing of the plants, there are fewer missing hills, and the yield is reduced less. But it often happens that certain fields of Sebago have plants that are uneven in height and vigor and produce rather inferior yields. Such fields may have been planted with seed stocks from fields having a high percentage of purple-top wilt hills.

It may be concluded that the tubers from purple-top wilted plants of the Katahdin and Sebago varieties are not suited for seed purposes. Even the firm tubers from diseased plants and the tubers from healthy stalks of diseased plants gave high percentages of missing and nonproductive hills when planted.

## RECOVERY OF SEED STOCKS FROM PURPLE-TOP WILT

**Effect on Plant Symptoms and Yield.** Studies conducted in previous years indicated that seed stocks recover from the purple-top wilt disease and produce normal or nearly normal crops.

In 1941, Katahdin and Sebago seed stocks one and two years removed from the original onset of purple-top wilt were compared with healthy seed stocks of the same varieties regarding the effect of the disease on plant growth and yield. The results of this experiment are summarized in Table 4. Katahdin variety seed stock one year removed from the disease produced only 19 per cent normal plants. Seed stocks of the same variety two years removed produced 92 per cent normal plants. The yield for the seed stock one year removed from purple-top wilt was 23 barrels an acre compared with 107 barrels an acre for the seed stock which had recovered. Figure 6 shows the yield from a Katahdin plant one year removed from purple-top wilt compared with that from a recovered plant two years removed from the disease.

The Sebago seed stock one year removed from the disease produced 28 per cent normal plants compared with 97 per cent normal plants when the seed stock was two years removed. The yields for the Sebago seed stocks one and two years removed from the purple-top wilt disease were 73 barrels and 159 barrels, respectively.

In another experiment, tubers of the Katahdin and Sebago vari-

TABLE 4  
Effect of Purple-Top Wilt on Type of Plants Produced and Yield  
Following Recovery—1941

Variety	Kind of seed tubers	Kind of plants produced.				Yield per acre <sup>1</sup>	Least requirement for significance at 1% level
		Normal	Slightly dwarfed	Very dwarfed	No plants (missing hills)		
		%	%	%	%	Bbls. <sup>2</sup>	Bbls.
Katahdin	Healthy hills (controls)	100	0	0	0	114	15
	Purple-top wilt hills 1st year removed <sup>3</sup>	19	12	10	58	23	
	2nd year removed <sup>4</sup>	92	2	0	6	107	
Sebago	Healthy hills (controls)	100	0	0	0	176	31
	Purple-top wilt hills 1st year removed <sup>3</sup>	28	32	16	24	73	
	2nd year removed <sup>4</sup>	97	2	2	0	159	

<sup>1</sup> Based on 30 replicated 4-hill plots for each Katahdin yield given and 17 replicated 4-hill plots for each Sebago yield rate given.

<sup>2</sup> One barrel is 2.75 bushels.

<sup>3</sup> Hills having purple-top wilt were harvested in 1940 for planting in 1941.

<sup>4</sup> Hills having purple-top wilt were harvested in 1939 and the progeny planted in 1940 and 1941.



FIGURE 6. *Left:* Yield from Katahdin plant one year removed from purple-top wilt. Yield was 23 barrels per acre. *Right:* Yield from recovered plant two years removed from the disease. Yield was 107 barrels per acre.

eties were harvested in 1941 and planted in 1942. The tubers from purple-top wilt plants produced small dwarfed plants with very small yields. Some of the purple-top wilt seed tubers of the Katahdin variety failed to produce plants but formed small tubers attached to the mother seed tubers.

Tubers were selected from this material and were planted in the field in 1943. Observations were made regarding the symptoms of the plants which developed. The results of this experiment are summarized in Table 5. The seed stocks infected with purple-top wilt in 1941 produced apparently normal plants in 1943.

It should be observed also in Table 5 that an apical leafroll seed stock harvested in 1931 and perpetuated since then did not recover and the symptoms of the plants continued to be about the same as when originally selected.

Studies were continued in 1944 to learn whether the yielding ability of tubers from plants which had recovered from purple-top wilt would be affected.

Hills having the purple-top wilt disease were harvested in 1941 and 1942 and perpetuated in the field until 1944 when they were used for yield comparisons. The seed stocks were stored under identical



TABLE 5

Recovery in Katahdin and Sebago Seed Stocks Infected with  
Purple-Top Wilt in 1941

Source of seed stock	Number of tubers planted	Symptoms produced 1943	
		Sprouts	Plants
Purple-top wilt Katahdin plant selected 1941:			
small plant 1942	20	Normal	Normal
do.	7	Normal	Normal
do.	22	Normal	Normal
do.	5	Normal	Normal
do.	4	Normal	Normal
do.	7	Normal	Normal
No plant produced 1942, small tubers on mother tuber used as seed	10	Normal	Normal
do.	8	Normal	Normal
Purple-top wilt Sebago plant selected 1941:			
small plant 1942	20	Normal	Normal
do.	40	Normal	Normal
Apical leafroll selected 1931	20	Normal	Slightly dwarfed rolled apical leaves. Foliage reddish colored.

conditions and received the same cultural treatments during the season. Eighteen 4-hill plots were planted from each seed lot. The tubers were harvested by hand and the weights of tubers obtained were recorded in the field.

The yield from the seed stocks which had recovered from purple-top wilt was in no case significantly less than for the healthy control seed lots (Table 6). Seed lots 1, 2, 5, and 6 yielded somewhat more than did the healthy controls and lot 3 only two barrels less.

Thus the data secured in 1944 confirm the conclusion from results obtained in 1941 and 1943, that the purple-top wilt disease does not permanently depress the yield rate after the seed stock has recovered from the shock of the initial infection. It should be mentioned that apical leafroll in contrast always causes a marked reduction in the yield rate, chiefly because the tubers are undersized.

**Effect on Immunity.** The question naturally arises as to whether a seed stock that has recovered from purple-top wilt is immune to the disease.

An experiment was conducted in 1944 to determine whether seed from infected plants would produce immune plants. Katahdin and Sebago seed stocks selected in 1941 and 1942 from purple-top hills were used for these studies. All of these seed stocks had recovered from the disease and had produced normal plants and a good crop in 1943.

TABLE 6

Yield of Seed Stocks That Had Recovered from Purple-Top Wilt—1944

Seed lot	Variety	Source of seed stock <sup>1</sup>	Yield per acre <sup>2</sup>	Significance <sup>3</sup>
			Barrels <sup>4</sup>	
1	Sebago	Purple-top wilt plants selected 1941	127	N.S.
2		Purple-top wilt plants selected 1942: Progeny from wilted plants	129	N.S.
3		Progeny from medium soft tubers	122	N.S.
4		Healthy controls	124	—
5	Katahdin	Purple-top wilt plants selected 1942: Progeny from soft tubers	121	**
6		Progeny from hard tubers	109	N.S.
7		Healthy controls	100	—

<sup>1</sup> Hills having purple-top wilt were harvested in 1941 and 1942 and were perpetuated in the field each year until 1944 when they were used for these yield studies.

<sup>2</sup> Based on 18 replicated 4-hill plots for each yield rate given.

<sup>3</sup> N.S.—Differences not statistically significant. \*\* Differences highly significant.

<sup>4</sup> One barrel is 2.75 bushels.

The seed was planted by hand along the border of a field where it was expected the disease would be prevalent. Some of the tubers were planted whole while others were cut and planted as is commonly done in Maine. This was done because it was considered that possibly the disease (or symptoms similar to those of purple-top wilt) might result from infection occurring through the freshly cut surfaces of the seed pieces.

The results of this experiment are summarized in Table 7. It may be noted that very little purple-top wilt was present in the plants in this test in spite of the fact that the six-spotted leafhopper was abundant. Aster yellows also was prevalent in an adjacent vegetable garden on one side and a weedy grass plot on the other side. The six-spotted leafhopper was so abundant that every lettuce plant in two nearby plots contracted aster yellows. This disease also was prevalent in carrots and other cultivated and wild plants grown in the vicinity of the potatoes which were being tested for immunity from purple-top wilt. The fact that purple-top wilt did not become more prevalent under these conditions is interesting and needs further investigation.

Although purple-top wilt was not prevalent in these plots, the data indicate that the seed stock which had recovered from purple-top wilt was not immunized from further infection. A trace of purple-top wilt developed in Lots 1, 6, and 7 (selected in 1941) and in Lots 8 and 9 (selected in 1942) (Table 7).

The data also show that the disease may appear in plants that are grown from uncut seed tubers.

TABLE 7

Development of Purple-Top Wilt in Katahdin and Sebago Plants Grown from Seed Stocks That Had Recovered from the Disease—1944

Lot No.	Variety	Year selected as purple-top wilt <sup>1</sup>	Kind of seed pieces planted	No. plants in test	Purple-top wilt developing in plants <sup>2</sup>
					Per cent
1	Katahdin	1941	Whole tubers	25	4.0
2		1941	Cut tubers	25	0
3		1942	Whole tubers	100	0 (+2 ?) <sup>3</sup>
4		1942	Cut tubers	100	0
5		Healthy control	Cut tubers	125	1.6(+1.6?) <sup>3</sup>
6	Sebago	1941	Whole tubers	25	4.0
7		1941	Cut tubers	25	4.0
8		1942	Whole tubers	75	1.3(+6.6 ?) <sup>3</sup>
9		1942	Cut tubers	75	1.3(+2.6 ?) <sup>3</sup>
10		Healthy control	Cut tubers	75	1.3(+1.3 ?) <sup>3</sup>

<sup>1</sup> Indicates year the seed stock was selected as being purple-top wilt.

<sup>2</sup> Purple-top wilt developing in field in plants from seed stocks previously infected with purple-top wilt.

<sup>3</sup> Number in parentheses represents plants that possibly had purple-top wilt but with diagnosis not definite.

## TRANSMISSION OF PURPLE-TOP WILT, APICAL LEAFROLL, AND HAYWIRE BY GRAFTING

**Grafts to Potato.** Attempts were made in 1940 to transmit purple-top wilt, apical leafroll, and "haywire" by grafting. The "plug," "splice," and inarch grafting methods were used in attempts to transmit these diseases.<sup>6</sup>

The results of these studies are summarized in Table 8. Of the 40 healthy plants that were grafted with purple-top wilt material by the inarch method, 30 produced tubers with weak sprouts, thereby showing that the virus was transmitted. However, no current-season foliage symptoms of purple-top wilt occurred. It is of interest that 5 of these inarch grafts produced symptoms of apical leafroll. This resulted because the symptoms of the two diseases are very similar during the early stages and apical leafroll plants were used as the source of inoculum instead of purple-top wilt as intended.<sup>7</sup>

<sup>6</sup> The plug grafting method consists of removing a plug or core from a diseased tuber with a cork borer and inserting it into a hole of slightly smaller diameter in a healthy tuber. When making the splice grafts, diseased and healthy tubers are cut in half with a sharp knife. The freshly-cut surface of a diseased tuber is applied to that of a healthy tuber and held in place with a rubber band until they have grown together. The inarch graft method consists of bringing shoots of healthy and diseased plants together so they can be united. A tongue cut in the stem of one plant is inserted beneath a similar tongue in the other plant and the two held in place by grafting tape.

<sup>7</sup> The writers on several occasions have confused the two diseases at the early stage. It is of interest also that other potato students have diagnosed apical leafroll as being purple-top wilt until they were shown that the disease was perpetuated in the seed tubers.



TABLE 8

Summary of Attempts to Transmit Purple-Top Wilt, Apical Leafroll, and "Haywire Viruses" by Grafting to Katahdin Variety

Kind and source of disease	Grafted onto	Grafts in test			Disease symptoms produced
		Kind	Total No.	No. infected	
Purple-top wilt plants, current season, Katahdin	Young plants	Inarch	40	30	Weak sprouts in some tubers of progeny
				5	Apical leafroll
Purple-top wilt tubers, current season, Katahdin <sup>1</sup>	Tubers	Plug	15	0	—
Ditto	Tubers	Splice	9	0	—
Ditto, except Sebago	Tubers	Splice	8	0	—
Ditto, except Chippewa	Tubers	Plug	4	0	—
Healthy plants recovered from purple-top wilt, Katahdin <sup>2</sup>	Plants	Inarch	5	0	—
Ditto, except Sebago	Plants	Inarch	5	0	—
Apical leafroll, Spaulding Rose <sup>3</sup>	Plants	Inarch	1	1	Apical rolling and colored foliage
Ditto, except Triumph <sup>4</sup>	Plants	Inarch	1	1	Ditto
Ditto, except Katahdin <sup>2</sup>	Tubers	Splice	5	4	Ditto
Ditto, except Spaulding Rose <sup>3</sup>	Tubers	Splice	5	5	Ditto
"Haywire" tubers, Triumph <sup>4</sup>	Tubers	Plug	23	6	Chlorosis and dying No tubers formed
Ditto	Splice	Splice	12	2	Ditto

<sup>1</sup> Tubers harvested from plants having purple-top wilt.

<sup>2</sup> Progeny from plants 2 years removed from purple-top wilt.

<sup>3</sup> Progeny from apical leafroll plants harvested in 1928 and 1929. Symptoms remained unchanged.

<sup>4</sup> Selected from seed stock shipped from Nebraska.

Purple-top wilt was not transmitted by plug or splice grafting when tubers from current-season infected plants or from plants that had recovered from purple-top wilt were used. No symptoms appeared in the plants grown from the healthy parts of the grafts and the disease was not perpetuated in the seed tubers from the healthy parts. McLeod (15) stated that purple-top wilt is tuber borne but rarely beyond the second generation and Self (21) reported that the disease was only occasionally perpetuated through aerial tubers, indicating that in most cases it probably does not live as long as the plant lives. In contrast the present writers have found that apical leafroll is readily perpetuated in the aerial tubers. Leach and Bishop (12) likewise concluded that the purple-top wilt virus does not survive long in the potato plant.

It can be seen further from the data in Table 8 that apical leafroll was readily transmitted by both the inarch and the splice graft methods. "Haywire" was transmitted by the plug and splice grafts, but no tubers were formed because the plant was injured by the causal virus and died prematurely. The results show that the apical leafroll and "haywire" viruses are different from that of purple-top wilt.

**Grafts to Tomato.** MacLeod found that the tomato (*Lycopersicon esculentum*) is a valuable plant for identifying the bunchy-top or purple-

top wilt virus (14, 15, 16). The writers, in view of McLeod's studies, compared the symptoms produced by purple-top wilt, apical leafroll and witches'-broom virus when transmitted into Marglobe tomato plants by inarch grafts.

The results of this experiment are summarized in Table 9. The apical leafroll virus, from both the Katahdin and the Kennebec potato variety, caused an abrupt downward bending of the tomato leaves and an upward rolling of the leaflets. Very little or no chlorosis was observed on the infected tomato plants. In some cases, secondary roots were formed on the tomato plants at the union of the grafts. The tomato fruits, when formed, were small and in some cases failed to develop and died.

TABLE 9

Reaction of Marglobe Tomato Plants Inoculated by Inarch-Grafts with Apical Leafroll, Purple-Top Wilt, and Witches'-Broom Viruses in Potato

Kind and source of disease	Plants inoculated		Symptoms resulting
	Total number	Number infected	
Apical leafroll, Katahdin <sup>1</sup>	8	4	Abrupt downward bending of petioles of tomato leaves. Slight upward rolling of leaflets.
Apical leafroll, Katahdin <sup>1</sup>	7	6	Abrupt downward bending of petioles of tomato leaves, slight upward rolling and chlorosis, small fruit, roots formed at union of graft.
Apical leafroll, Kennebec <sup>2</sup>	11	5	Abrupt downward bending of petioles of tomato leaves. Slight rolling of leaflets.
Healthy Kennebec	2	0	Normal
Purple-top wilt, Katahdin current season	6	5	Purple-top wilt tomato. Apical leaves rolled distinctly, chlorotic and reddish colored. Plants died.
Purple-top wilt, Katahdin progeny, recovered plant	4	0	Normal
Witches'-broom	6	4	Slight downward bending of petioles of tomato leaves.
		1	Aerial tubers at union of graft.

<sup>1</sup> Found in a seed lot in 1931 and perpetuated since then with little change in symptoms.

<sup>2</sup> Found in a seed lot in 1948 and perpetuated since then with little change in symptoms.

The symptoms produced by the witches'-broom virus were quite similar to those produced by apical leafroll, although the downward bending of the leaves was less pronounced. Aerial tubers were formed on the potato plant at the graft union in one case.

The grafts with purple-top wilt virus resulted in rather marked symptoms like those produced on potatoes. The top leaves of the tomato plant became distinctly chlorotic and rolled with some reddening. The infected plants began to die soon after the symptoms had developed.

The grafts with the progeny from potato plants that had recovered from purple-top wilt produced no symptoms, indicating that the virus was not present. This fact confirms the observations of Leach and Bishop (12), Self (21), and MacLeod (15) that the purple-top wilt virus does not live for long periods in the tubers from infected plants.

### TRANSMISSION EXPERIMENTS WITH THE SIX-SPOTTED LEAFHOPPER AND THE TARNISHED PLANT BUG

**Using Leafhoppers Caught in the Field.** Evidence supporting the conclusion that purple-top wilt is caused by the aster-yellows virus (*Chlorogenus callistephi* Holmes) has been presented by a number of workers (9, 11, 12, 21, 24).

The writers attempted in 1939 to transmit aster yellows virus to healthy Green Mountain plants using the six-spotted leafhopper (*Macrostelus divisus* (Uhl.)). The insects were netted in the field and transferred to caged annual sow thistles (*Sonchus asper*) infected with aster yellows. The insects fed for 10 days on the plants having aster yellows and were then transferred to healthy Green Mountain plants under cloth cages in the greenhouse. No current-season symptoms of purple-top wilt became apparent as a result of the insect feeding. The apical leaves of the potato plants, however, appeared to be somewhat crisp and hard. The tubers from the inoculated plants were harvested

TABLE 10

Summary of Inoculations using Six-Spotted Leafhopper and Tarnished Plant Bug in Attempts to Transmit Aster Yellows Virus to Potatoes, 1939-1940

Inoculation No.	Insect used	Number insects used	Number tubers harvested	Symptoms in plant progeny	
				Number normal	Number diseased <sup>1</sup>
1	Six-spotted leafhopper	10	2	0	2
2	"	10	4	1	3
3	"	10	2	2	0
4	"	10	2	1	1
5	"	10	2	1	1
6	"	10	2	0	2
7	"	50	1	0	1
8	"	50	3	2	1
9	"	100	2	1	1
10	"	100	2	0	2
11	"	100	6	3	3
12	"	100	2	0	2
13	"	110	2	1	1 <sup>2</sup>
14	Tarnished plant bug	50	2	2	0
15	None	—	3	3	0

<sup>1</sup> Characterized by dwarfed plants with spindling wiry stems and enlarged nodes and considered to be symptoms of apical leafroll.

<sup>2</sup> Similar to witches'-broom.



and grown the following year in the field to determine whether the insects had transmitted the disease.

The results of this experiment are summarized in Table 10. The tubers from 12 of the plants inoculated with aster yellows with the six-spotted leafhoppers caught in the field produced abnormal plants.

The plants produced by these tubers were more or less dwarfed and had spindling and wiry stems and enlarged nodes. These symptoms appeared to be very similar to those of apical leafroll, a disease previously noted under natural field conditions in Spaulding Rose, Irish Cobbler, and Katahdin potato varieties (20). Plants with similar symptoms also were noted in experimental seed plots conducted in 1940.

Inoculation number 13, Table 10, produced plants with symptoms that were very similar to those of witches'-broom (Fig. 7). This is very interesting in view of the fact that the vector of this disease is not



FIGURE 7. Progeny from Sebago plant inoculated with the six-spotted leafhopper (*Macrostelus divisus* (Uhl.)), which had fed on caged annual sow thistle (*Sonchus asper*). Note the spindling stems and numerous small tubers resembling symptoms of witches'-broom.

known and that Wright (23) found evidence of a possible relationship between witches'-broom and the aster yellows virus.

The tubers from the plant that was inoculated with tarnished plant bugs (*Lygus oblineatus* (Say.)) that had fed on aster yellows produced normal plants. Likewise, the tubers from the uninoculated plants produced normal plants the following year.

In 1943 another attempt was made to transmit aster yellows to healthy Katahdin and Green Mountain plants using the six-spotted leafhopper as the vector. For this experiment the hoppers were netted in the field and placed in large square cages and there allowed to feed on actively growing healthy potato plants in association with the aster yellows disease in the oxeye daisy (*Chrysanthemum leucanthemum*). No disease symptoms became apparent as a result of the insects having fed on the healthy potato plants. The plants on which the insects had fed were harvested and the tubers planted in the field in 1944 for further observation.

All five tubers from one inoculated plant failed to germinate when planted (Table 11). This failure to germinate was no doubt the result of the insect inoculations and probably was caused by the aster yellows virus. The plants that were produced from the tubers from the inoculated plants did not develop purple-top wilt symptoms. However, the tubers from 20 of the inoculated Katahdin plants and 11 of the inoculated Green Mountain plants produced rather dwarfed and late maturing plants with enlarged nodes and slightly rolled leaves.

**Using Leafhoppers Reared in the Greenhouse.** The studies summarized in Tables 10 and 11 showed that the six-spotted leafhoppers caught in the field and fed on annual sow thistle plants having aster yellows transmitted a disease which appeared to be similar to apical leafroll. However, it was not known whether this disease was

TABLE 11

Results of Inoculating Potato Plants using the Six-Spotted Leafhopper.  
1943

Variety	No. cages	No. plants inoculated	Disease in progeny of inoculated plants	
			Purple-top wilt hills <sup>1</sup>	Hills abnormal <sup>2</sup>
Katahdin	32	128	0 (1 hill with 5 tubers failed to germinate)	20
Green Mountain	32	115	0	11

<sup>1</sup> No current seasonal symptoms of purple-top wilt were apparent in 1943 as a result of the inoculations.

<sup>2</sup> Some plants were slightly dwarfed and late maturing with slightly rolled leaves and enlarged nodes indicating that a disease had been transmitted by the hoppers.

caused by the aster yellows virus from the diseased sow thistle plants or by another virus carried by the insect caught in the field. In order to answer this question, experiments were conducted with originally nonviruliferous insects reared in the greenhouse.

The experiments were conducted during the winter and summer months at Orono and Presque Isle, respectively. Nonviruliferous leafhoppers were reared on oats and the insect inoculations were made mostly in small cylindrical cages similar to those used by Leach and Bishop (12, fig. 12). Some of the inoculations to potatoes were done by confining the insects and the plants in sleeve cages like those used by Self (21). The insects, as far as was possible, were allowed to feed 10 to 12 days on the infected plants before being transferred to healthy plants.

Table 12 summarizes the results of these inoculations. Ninety-two young Katahdin potato plants were inoculated by the leafhoppers carrying the aster yellows virus. None of these inoculated potato plants developed definite purple-top wilt symptoms, although 11 plants had a slightly reddish pigmentation and rolled apical leaves during the current season. There was no wilting or early death of the potato plants and the tubers remained firm. The tubers from two of these pigmented plants failed to germinate, and the tubers from two others produced small weak plants similar to those produced by the purple-top wilt virus the year following infection. The plants which produced tubers that either failed to germinate or produced small weak plants possibly had purple-top wilt without the current-season symptoms becoming apparent before the plants died. Leach and Bishop (12) reported the incubation period for the virus in potatoes varied from 34 to 68 days (average 49 days) and Self (21) in one experiment found that purple-top wilt symptoms developed 34 to 47 days after the plants had been infected by the viruliferous six-spotted leafhoppers.

It can be noted from the data in Table 12, Series 1, that the tubers from seven of the plants inoculated with the aster yellows virus produced small plants with symptoms similar to those of apical leafroll. This indicated that the leafhoppers had also transmitted another disease which was different from purple-top wilt. It should be mentioned that the aster yellows virus used in this experiment was originally secured from several wild oxeye daisy plants and that possibly more than one virus was present. It is of interest here that MacLeod (14, 16) considers the bunchtop virus (purple-top wilt virus) in New Brunswick, Canada, to be similar to the aster yellows virus in certain respects, but not identical with the type strain.



TABLE 12

Summary of Inoculations to Potato and Asters with *M. Divisum* Using Aster Yellows, Purple-Top Wilt, Apical Leafroll, and Witches'-Broom Viruses as the Inocula

Series	Virus	Plant inoculated <sup>1</sup>	No. plants inoculated	No. plants infected	Symptoms produced	
					Current season	Progeny
1	Aster yellows <sup>2</sup>	Potato	92	11	Apical roll, red pigmentation	2 no germination, 2 small plants as for purple-top wilt 7 small plants rolled top small tubers as for apical leafroll
2	"	Asters	27	22	Aster yellows	—
3	"	Tomatoes	11	2	Chlorotic	—
4	"	Celery	5	0	None	—
5	Apical leafroll <sup>2</sup> large cage	Potato	32	0	None	—
6	Apical leafroll <sup>2</sup> sleeve cage	Potato	62	13	Apical rolling, red pigmentation aerial tubers	Small late plants, slightly rolled top leaves and wiry stems
7	Apical leafroll	Aster	46	1	Chlorotic	—
8	Purple-top wilt	Potato	108	0	None	None
9	"	Aster	46	0	None	—
10	Selected as purple-top wilt	Potato	5	1	Weak plant	As witches'-broom
11	From small plant with rolled top leaves <sup>4</sup>	Potato	4	1	None	Very late, dark green bushy plant. Tubers small and elongated
12	Witches'-broom <sup>5</sup>	Potato	8	0	None	None

<sup>1</sup> The Katahdin variety was used throughout these experiments.

<sup>2</sup> Secured from several greyed plants and transferred by leafhopper to aster and gulendula plants before being used to infect potatoes.

<sup>3</sup> Found in a Katahdin plant selected in 1941. The symptoms of the disease have remained the same since that date.

<sup>4</sup> Brought in by a potato inspector in 1943.

<sup>5</sup> Secured from Montana in 1940 in the Russet Burbank variety. Has been transmitted by grafts but not by insects.

The fact that some of the aster yellows and leafhopper inoculations yielded symptoms on potato plants that were similar to those of apical leafroll led to attempts to transmit this virus under controlled conditions. Thirty-two healthy Katahdin potato plants were confined in large outdoor cages with nonviruliferous six-spotted hoppers and potato plants having the apical leafroll disease. Some oat plants were permitted to grow in the cages to serve as food and a breeding host for the insects. The data in Table 12, Series 5, show that none of the inoculated plants in the large cages developed symptoms of the disease, either during the current season or in the progeny grown the following year.

The experiment was repeated confining the leafhoppers with the inoculated plants by means of sleeve cages. The insects were fed on plants having the apical leafroll disease and then were transferred to the healthy potato plants confined in small sleeve cages. The data in

Table 12, Series 6, show that 13 of the 63 inoculated plants developed foliage with red pigmentation, aerial tubers, and apical rolling. The tubers from these diseased plants produced small, late-maturing plants with slightly rolled apical leaves and wiry stems when grown the following year (Fig. 8).



FIGURE 8. *Left:* Progeny from Katahdin plant inoculated with six-spotted leafhopper forced to feed on apical leafroll potato. Note reduced size of plant and tubers and rolling of upper leaves. *Right:* Healthy control.

One hundred eight potato plants were inoculated with aster leafhoppers that had fed on purple-top wilt plants selected in the field. Table 12, Series 8, shows that none of the inoculated plants developed symptoms. In one instance (Table 12, Series 10), a plant selected as having purple-top wilt by a potato inspector produced symptoms of witches'-broom when used as a source of inoculum for the leafhopper transmission studies. Symptoms of witches'-broom also developed in one plant inoculated with aster leafhoppers that had been netted in the field and allowed to feed on plants infected by the aster yellows virus (Table 10; Series 13). However, the writers' attempts to transmit a certain strain of the witches'-broom virus with the six-spotted leafhopper failed (Table 12, Series 12).

Inoculation Series 11, Table 12, is of special interest. A small

plant with rolled apical leaves was brought to the laboratory for diagnosis by a potato inspector in 1943. Nonviruliferous leafhoppers were fed on a diseased plant of this material in 1945 and transferred to four healthy Katahdin plants in small cylindrical cages in the greenhouse. None of the inoculated plants showed current-season symptoms. However, the tubers from one of the inoculated plants produced rather small, late maturing plants with dark green bushy foliage and small, slightly elongated tubers when grown the following year. An attempt to transmit the disease back to healthy potatoes with the six-spotted leafhopper failed in 1948. It should be mentioned that similar attempts to transmit the "apical roll" resulting from the aster leafhopper inoculations (Table 12, number 1) using the aster yellows virus and healthy Katahdin plants also had negative results.

Forty-six inoculations each were made in an attempt to transmit the virus from both purple-top wilt and apical leafroll potato plants to asters with the six-spotted leafhopper (Table 12, Series 7 and 9). No aster yellows symptoms resulted from these inoculations. It should be noted that one aster plant inoculated with the hoppers that had fed on apical leafroll plants became chlorotic. This chlorosis may prove to be a symptom of apical leafroll on this host.

It should be recalled that a number of other workers also failed to transmit the aster yellows virus directly from purple-top wilt potato plants (9, 12, 14, 21, 24). Severin (22), however, reported having found in California a diseased volunteer potato plant from which he isolated the western aster yellows virus with a long winged form of *M. divisus*.

## CONTROL OF PURPLE-TOP WILT

It has been difficult to secure definite information on the control of purple-top wilt in Maine. The fact that the disease is of a virus nature, and considered by many research workers to be spread by the six-spotted aster leafhopper, suggests that applications of DDT or some other contact insecticides should be a good control measure.

Spray experiments including fungicidal treatments, with and without DDT, have been conducted at Aroostook Farm for the past 10 years. Practically perfect control of the six-spotted aster leafhopper was obtained with DDT applied 6 to 8 times during the growing season. However, the DDT treatments also practically eliminated the leafhoppers in the adjacent control plots. The amount of purple-top wilt in the above mentioned experimental spray tests was negligible even in the plots that received no DDT. Observations in farmers' fields, where



DDT was used freely, also support the contention that applications of the insecticide have greatly reduced the prevalence of purple-top wilt. Although it is possible that the control of the leafhoppers may not have been entirely the result of the DDT treatments, there appears to be strong reason to consider that DDT exerted considerable influence. Leafhoppers were abundant in surrounding fields where DDT was not used and from two to five per cent of the plants had purple-top wilt.

It also is apparent that a trace of purple-top wilt in a seed stock is less serious than is spindle tuber, mosaic, or leafroll. The question naturally has arisen as to whether certification officials should disqualify seed stocks because of the presence of purple-top wilt among the plants. The fact that the disease is not tuber borne or spread from from one potato plant to another, indicates that it cannot be controlled by roguing or by certification measures. Nevertheless, seed stocks containing high percentages of the disease should not be accepted for certification because experiments have shown that purple-top wilt greatly reduces the yield of some varieties.

The available information justifies the rejection of seed stocks having high percentages (more than five per cent) of purple-top wilt. It also may be practical in some cases to rogue from the field enough diseased hills to meet certain specified certification regulations. Growers, however, may find it difficult to eliminate purple-top wilt from a seed stock because the disease symptoms may continue to develop until the field is killed by frost or by maturity of the plants.

### SUMMARY

Purple-top wilt is an important potato disease which sometimes causes large losses. Seed potatoes from fields with high percentages of this disease often fail to grow, or produce many small weak plants, resulting in low yields.

The leafrolling symptom of purple-top wilt resembles the leafrolling associated with primary leafroll, with stem girdling caused by *Rhizoctonia* and *Botrytis*, with blackleg, and with *Verticillium* wilt. The symptoms caused by the purple-top wilt and the apical leafroll viruses are often confused.

Purple-top wilt plants produced tubers with varying degrees of wilting. In one experiment with the Katahdin variety, only 44 per cent of the tubers were firm and apparently normal, 20 per cent were slightly wilted, and 36 per cent were badly wilted and soft. Thirty-seven per cent of the apparently normal tubers, 41 per cent of the slightly wilted

and 81 per cent of the badly wilted tubers failed to grow and produce plants.

Symptoms of purple-top wilt sometimes are present in only one stalk or part of a plant. The cause of the disease, however, is then present not only in the tubers of the diseased stalk but also in many of the tubers from the apparently healthy stalks.

Purple-top wilt affects the Katahdin variety more than it does the Sebago variety. In the Sebago variety the disease causes less dwarfing of the plants, fewer missing hills and less reduction of yield.

It is concluded that the tubers from purple-top wilt plants of the Katahdin and Sebago varieties are not suited for seed purposes. Even the firm tubers from diseased plants and the tubers from healthy stalks of diseased plants gave higher percentages of missing and nonproductive hills when planted.

Purple-top wilt produced different symptoms after its perpetuation in seed stocks. The tubers from diseased plants produced only many missing hills and weak plants the year following infection. There was complete recovery the second year after the onset of the disease.

Apical leafroll, a virus disease often mistaken for purple-top wilt, in contrast was perpetuated in the seed stock with little or no recovery in symptoms or yields.

Seed stocks that originated from purple-top wilt plants that had recovered, were not immune to new infection by the disease.

No current-season symptoms of purple-top wilt were obtained with grafts to healthy potato plants. In contrast, apical leafroll and "haywire" viruses were readily transmitted by grafting methods to potatoes with consequent current-season symptoms. Inarch grafts with purple-top wilt, however, did produce weak sprouts in the seed tubers.

Purple-top wilt in potatoes when inarch grafted to tomato plants produced symptoms that were very similar to those of potatoes. Apical leafroll and witches'-broom on tomato caused a downward bending of the leaves and an upward rolling of the leaflets with little or no chlorosis.

Six-spotted leafhoppers (*Macrostelus divisus*) caught in the field were fed upon annual sow thistle (*Sonchus asper*) showing aster yellows symptoms, and were then used to inoculate potato plants. One inoculation produced witches'-broom symptoms. In other instances, tubers from inoculated plants produced plants with apical leafroll symptoms, such as wiry stems and enlarged nodes.

Katahdin potato plants inoculated with the aster yellows virus in six-spotted leafhoppers reared in cages, developed no definite symptoms

of purple-top wilt except that some of the plants produced tubers that failed to germinate or produced very small plants. Symptoms similar to those produced by the apical leafroll virus also were produced. The apical leafroll virus in potatoes, however, was not transmitted by hoppers to young potato plants.

The progeny from potato plants inoculated with tarnished plant bugs (*Lygus oblineatus*) were normal.

Observations indicate that six to eight applications of DDT during the growing season will control both the six-spotted leafhoppers and the spread of purple-top wilt.

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